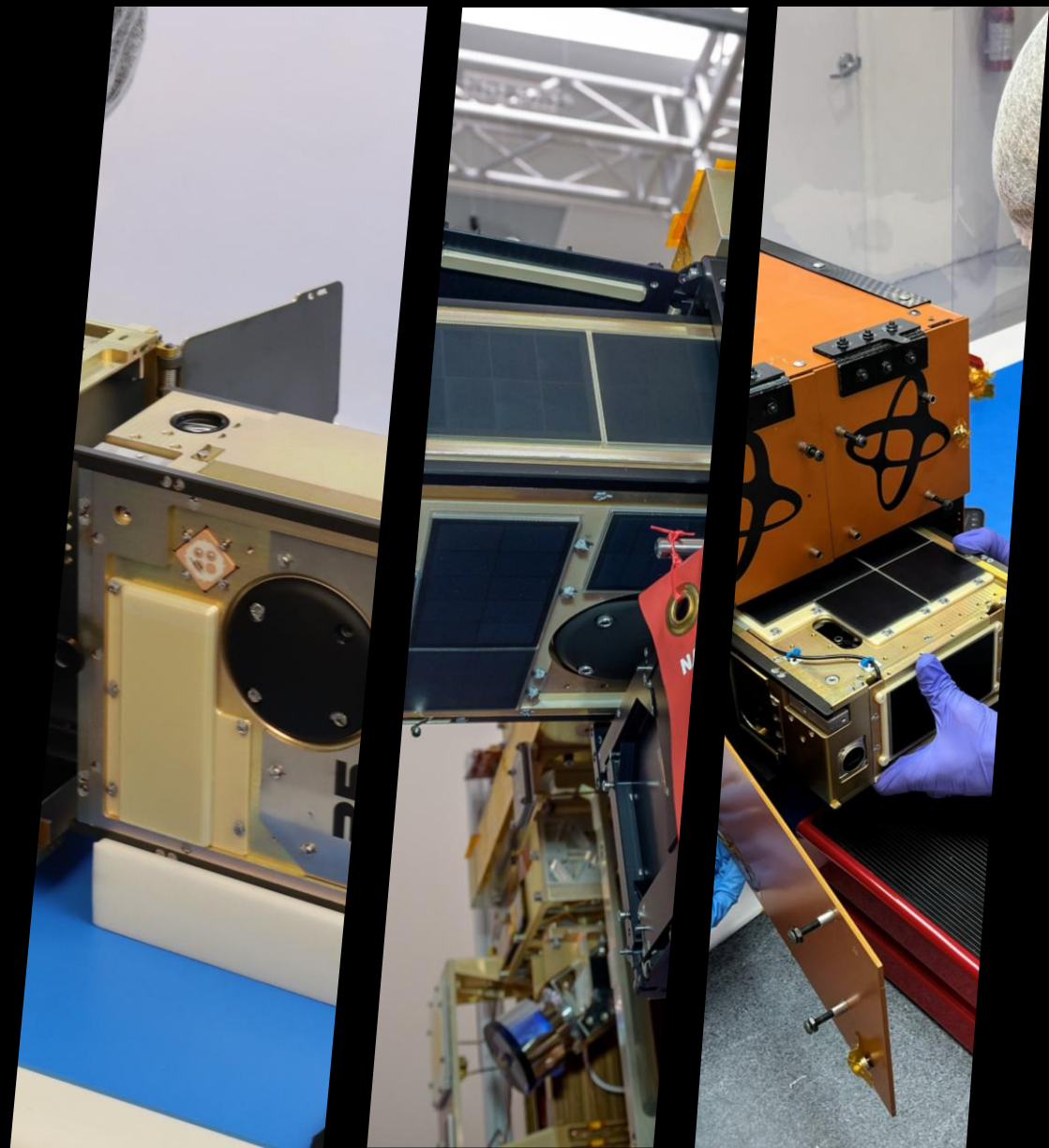
R5 Year in Review
Spacecraft 7, Spacecraft 10, & Spacecraft 9

Sam Pedrotty, NASA JSC / R5 PM

August 2026



Trade names are used in this presentation for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by the National Aeronautics and Space Administration.

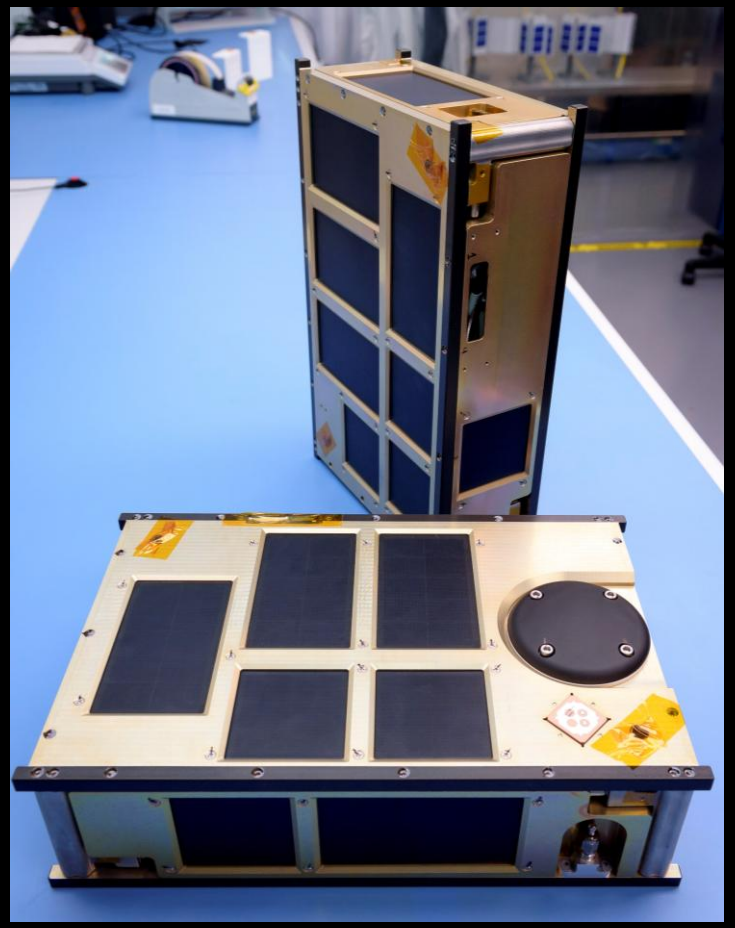
Purpose

These charts were created for the 2026 Small Satellite Conference to accompany the paper “R5 Spacecraft 7, 9, and 10: Proximity Operations, Optical Comm, and Edge Compute.”

R5 Overview

Realizing **R**apid, **R**educed-cost, high-**R**isk **R**esearch (R5) project

- Funded by RTMD/SSDS and JSC/EA
- Enables rapid payload demonstration in space
  - **< 12 months ATP-delivery**
  - **< $1M/mission full cost**
- Pioneering **new, lean process and nontraditional component use** (C*OTS*)

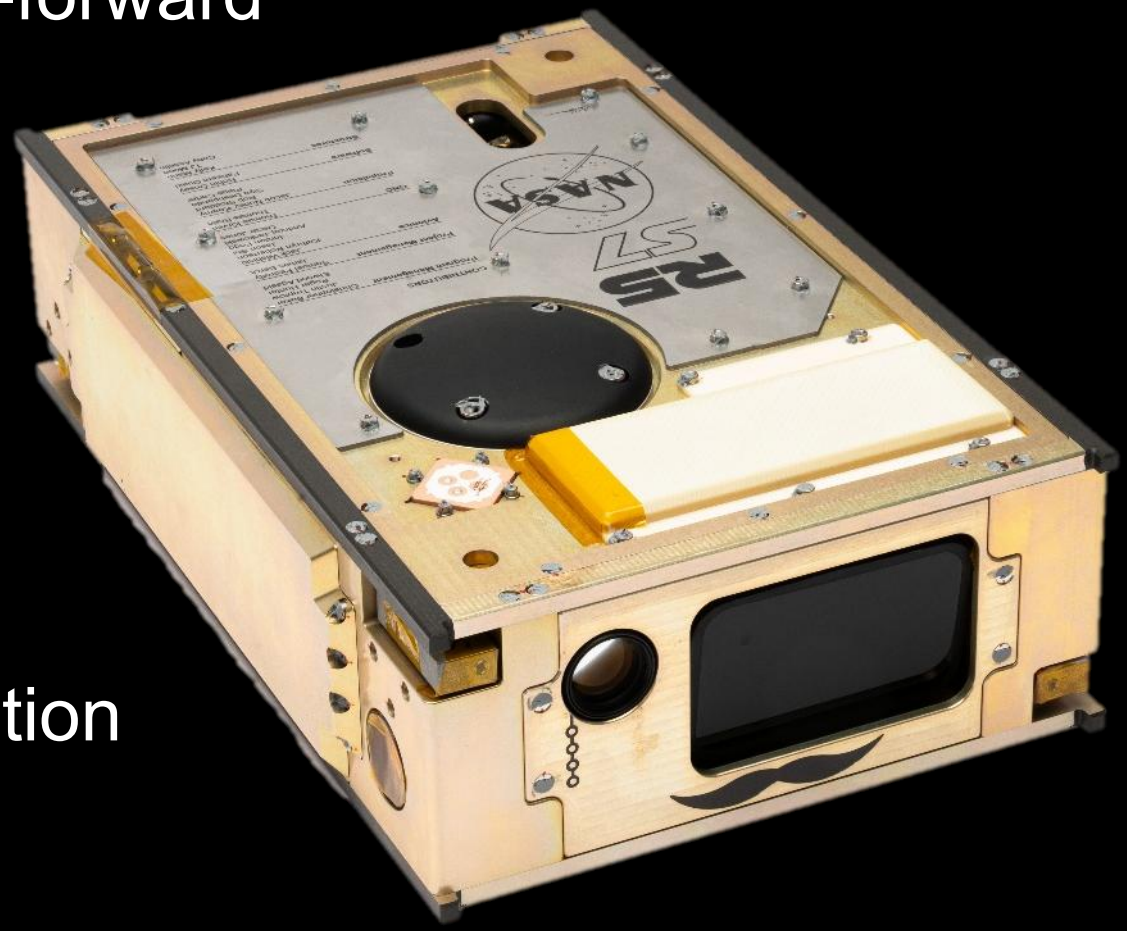


Spacecraft 2 and 4, launched 2024

Other publications: https://ntrs.nasa.gov/search?q=R5%20cubesat&

R5-S7: Overview

- Objective: Demonstrate inspection-forward Prox Ops with the R5 paradigm
  - Repeatable launch/ops opportunity
- 6U XL CubeSat
  - Evolution of R5-S5
- 6 DOF control via cold-gas prop
- Industrial LiDAR for relative navigation

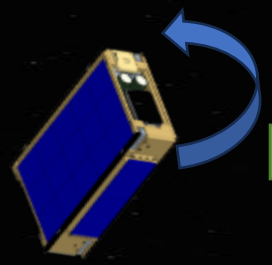


R5-S7: ConOps



1. Client deploys R5 (D+0)

- Deploy Speed: 0.3 m/s
- SUBORBITAL

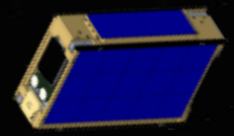


2. R5 Init (D+40s)

R5 immediately powers on and tracks client (3DOF control, range and bearing to client)

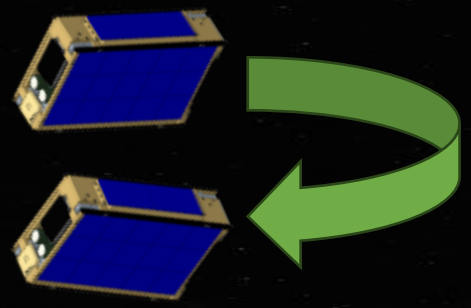
R5 starts 6DOF control, braking, and transmitting telemetry

3. R5 Braking (D+47s)



R5 comes to a stop and tracks client

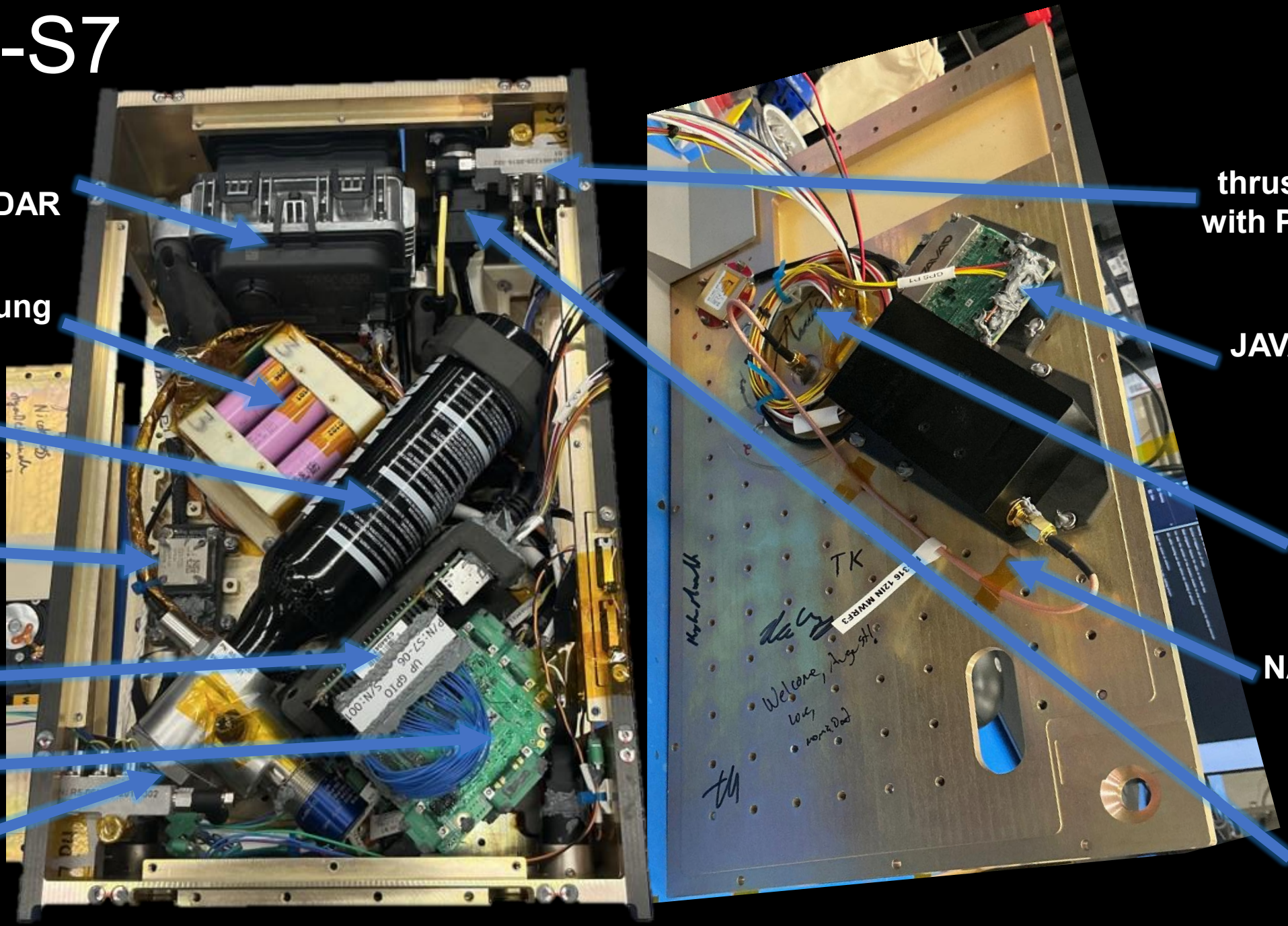
4. R5 All Stop (D+70s)



5. R5 Holds Position

R5 continues pointing, holds position, transmits data

R5-S7



Microvision Movia 60 LiDAR

Custom 1S6P battery (Samsung 30Q cells)

Tippmann 13in3 tank

Epson G370 IMU

UP CHT01 computer

Custom IO/PDU

Custom manifold

Custom thruster pods with Parker C7 valves

JAVAD TR-2S GPS

NAL SAF 2040B antenna

NAL A3LA-RS radio

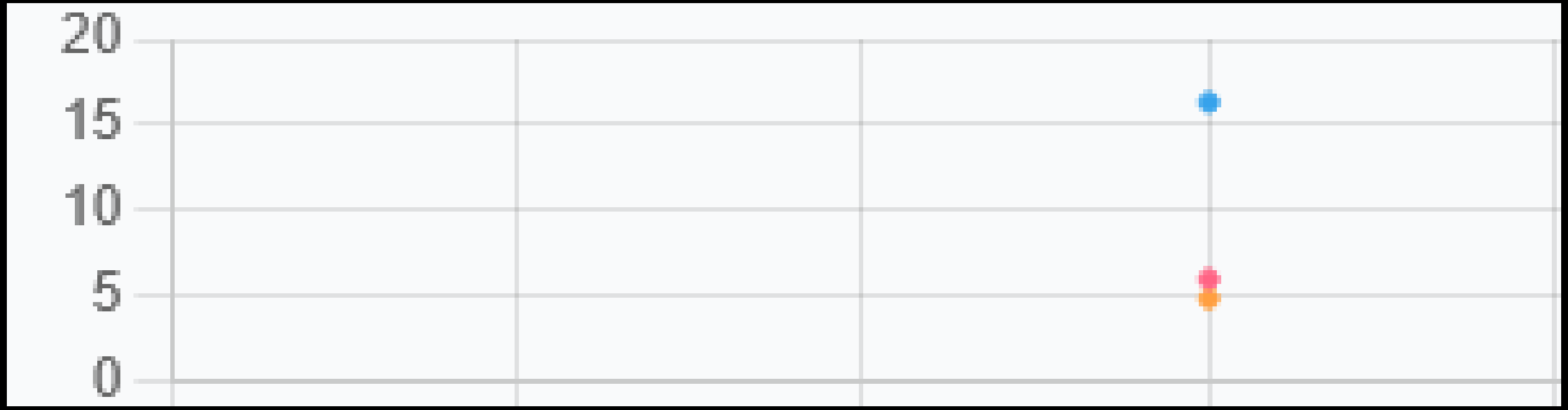
Ximea MQ013 camera

R5-S7: Results

Launched on Transporter 15

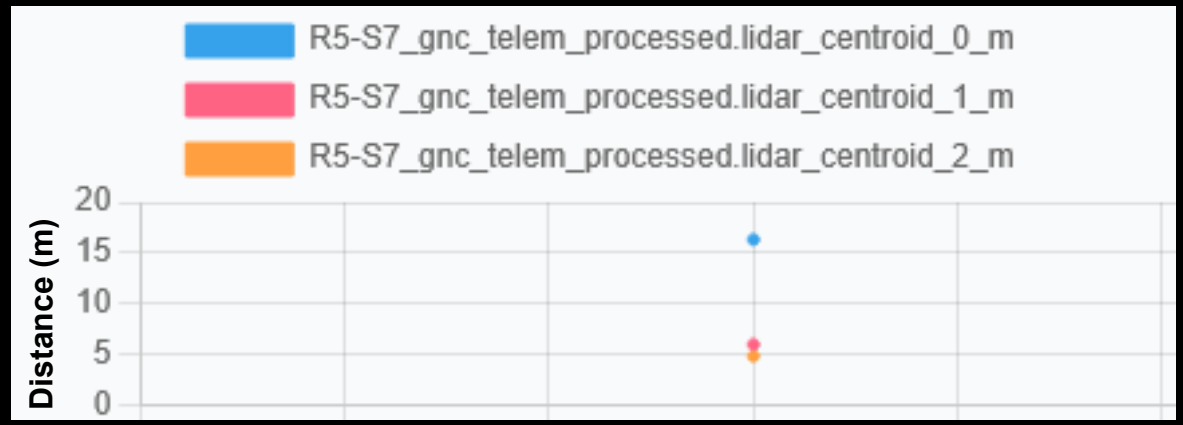
- Schedule: 5 months (kickoff to delivery, approximate)
- Cost: $1.2M (includes specialized launch, approximate)
- Mission fully successful
- Flight results...

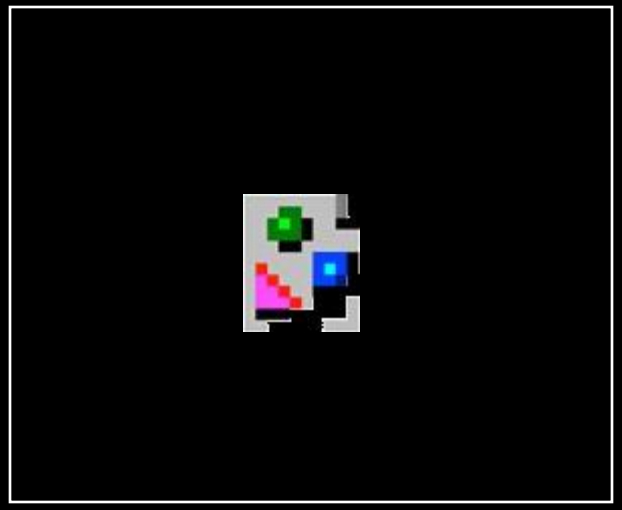
R5-S7: Results

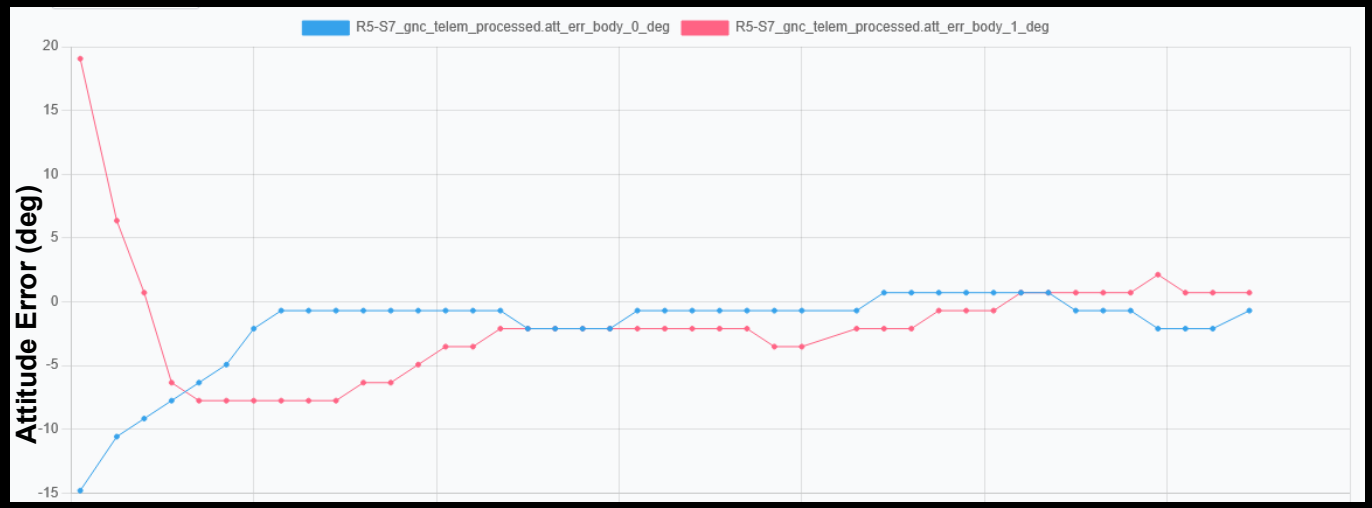


R5-S7: Results

- Received 4 Iridium® SBD® messages
  - 1060 bytes of data
- LiDAR return
- Attitude error
- Image header

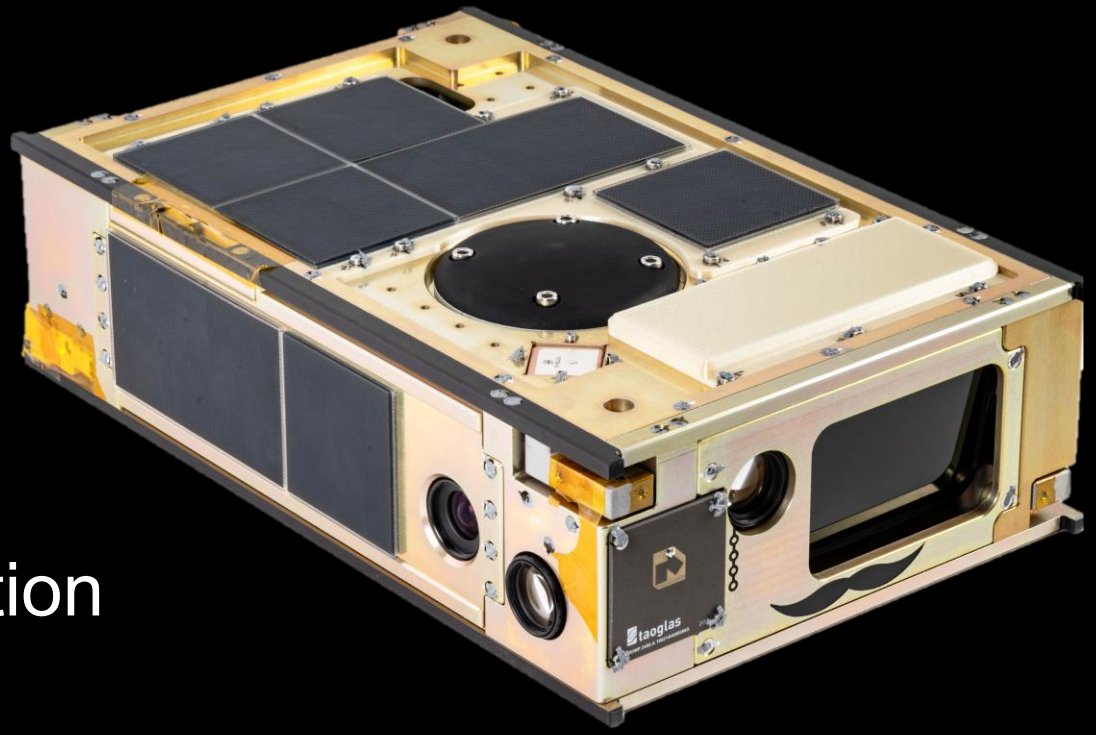




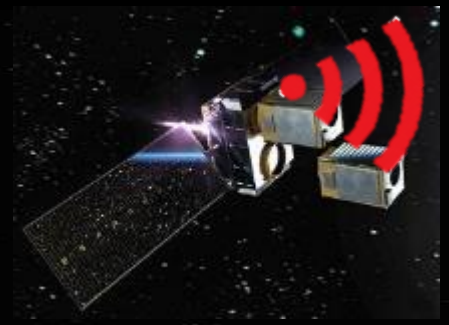


R5-S10: Overview

- Objective: Demonstrate inspection-forward Prox Ops *evolution*
  - Add crosslink
  - Add event camera secondary payload
- 6U XL CubeSat
  - Evolution of R5-S7
- 6 DOF control via cold-gas prop
- Industrial LiDAR for relative navigation

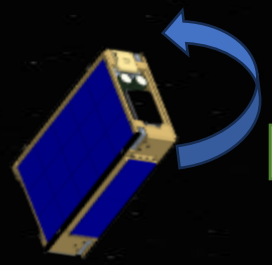


R5-S10: ConOps



1. Client deploys R5 (D+0)

- Deploy Speed: 0.3-1 m/s

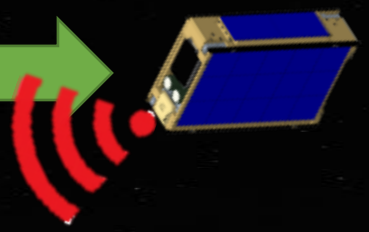


2. R5 Init (D+40s)

R5 immediately powers on and tracks client (3DOF control, range and bearing to client)

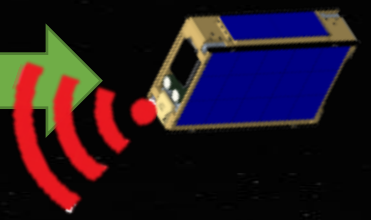
R5 starts braking, initializes crosslink, and transmits images and point clouds of client for downlink

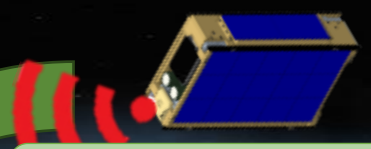
3. R5 Braking (D+40s – D+100s)



R5 comes to a stop and tracks client

3. R5 All Stop (D+100s)





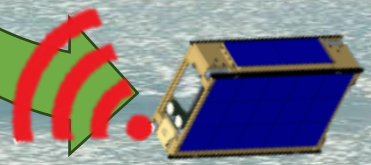
5. R5 Approach 2 (D+25min)

R5 approaches to 10m and holds



4. R5 Approach 1 (D+5min)

R5 approaches to 30m and holds



6. R5 Depart D+35min

- Gated by command, safeguards, or timeout
- Transitions to post prox ops ConOps
- Starts secondary mission (duration 1 year)

Depart triggered at any time if:

- Ground-issued command for depart is received
- Prop level drops below threshold
- Battery voltage drops below threshold

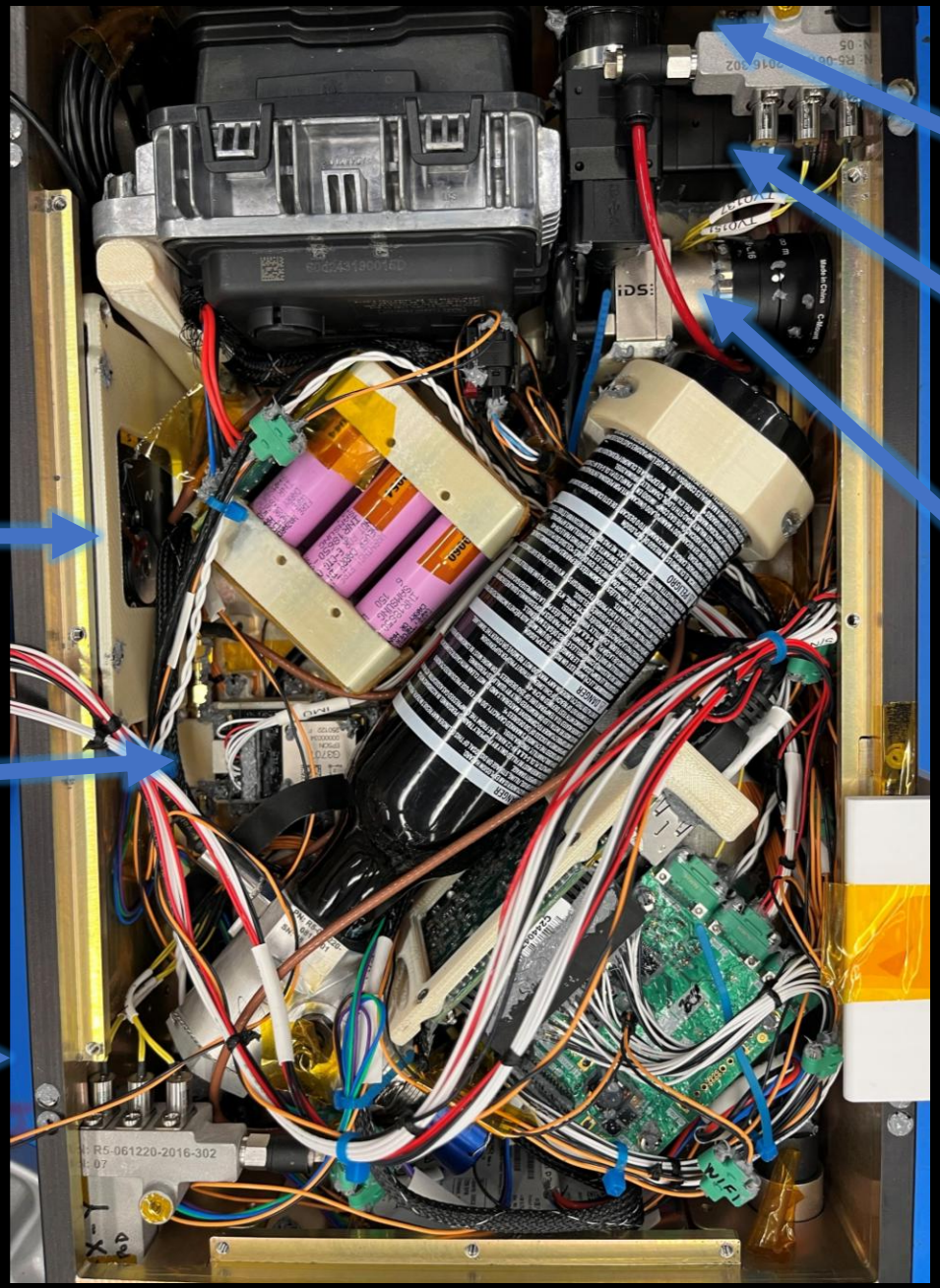
R5-S10

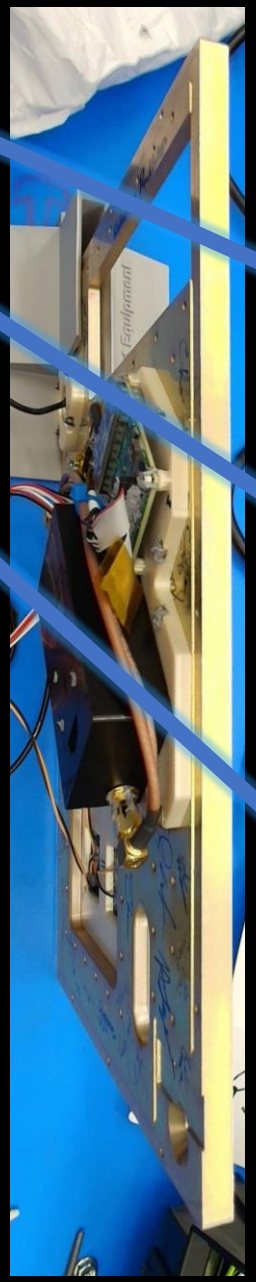
Very similar to R5-S7

HDD-based reaction control wheels

Netis WF2190 WiFi

Voltaic Systems P123 and P124 solar panels





Taoglas WDMP.2458.A WiFi antenna

Ximea MC023 camera

IDS UE-39B0XCP-E event camera

R5-S10: Results

Launched on Transporter 16

- Schedule: 5 months (kickoff to delivery, approximate)
- Cost: $900k (launch provided in-kind, approximate)
- Flight results...

R5-S10: Results

...coming soon!

R5-S9: Overview

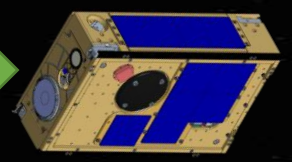
- Objective: Demonstrate Sandia National Laboratories payload
  - Add optical comm system
  - Add Iridium 9704 radio
  - Add radiation measurement
- 6U XL CubeSat
  - Evolution of R5-S10
- 6 DOF control via cold-gas prop
  - ~~Add reaction control wheels~~
- GPS and COTS-camera-based star trackers for navigation



R5-S9: Sandia SDA & MDA ConOps

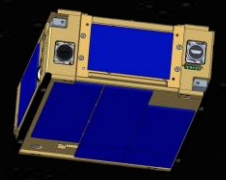


1. LV Achieves Orbit



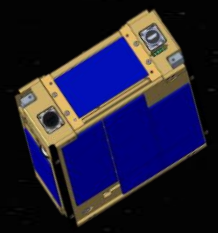
2. S9 Deploy/ Checkout

- S9 deploys from upper stage, powers on and self-commissions
- Completes checkouts



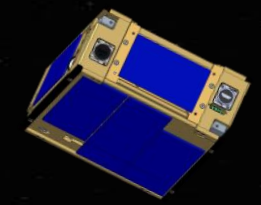
3. S9 Payload Prep

- S9 sets position/time
- S9 activates payload



4. Payload Ops

- Payload commands bus to point
- Payload images regions and processes
- Payload creates telemetry and sends to bus



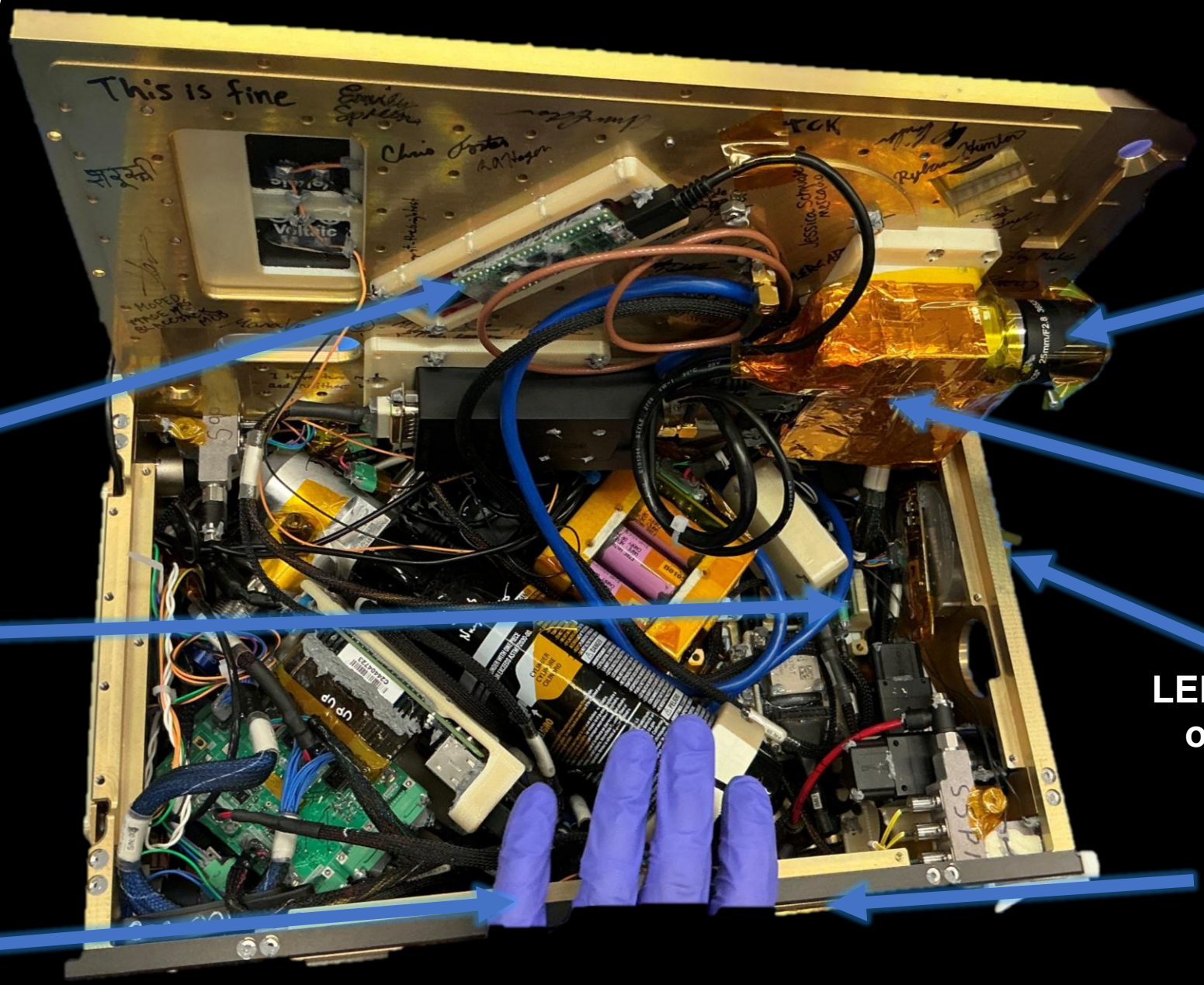
5. Payload Ops

- Payload data downlink/command uplink
- Perform additional observations

[Repeats over multiple power cycles]

R5-S9

Very similar to R5-S10



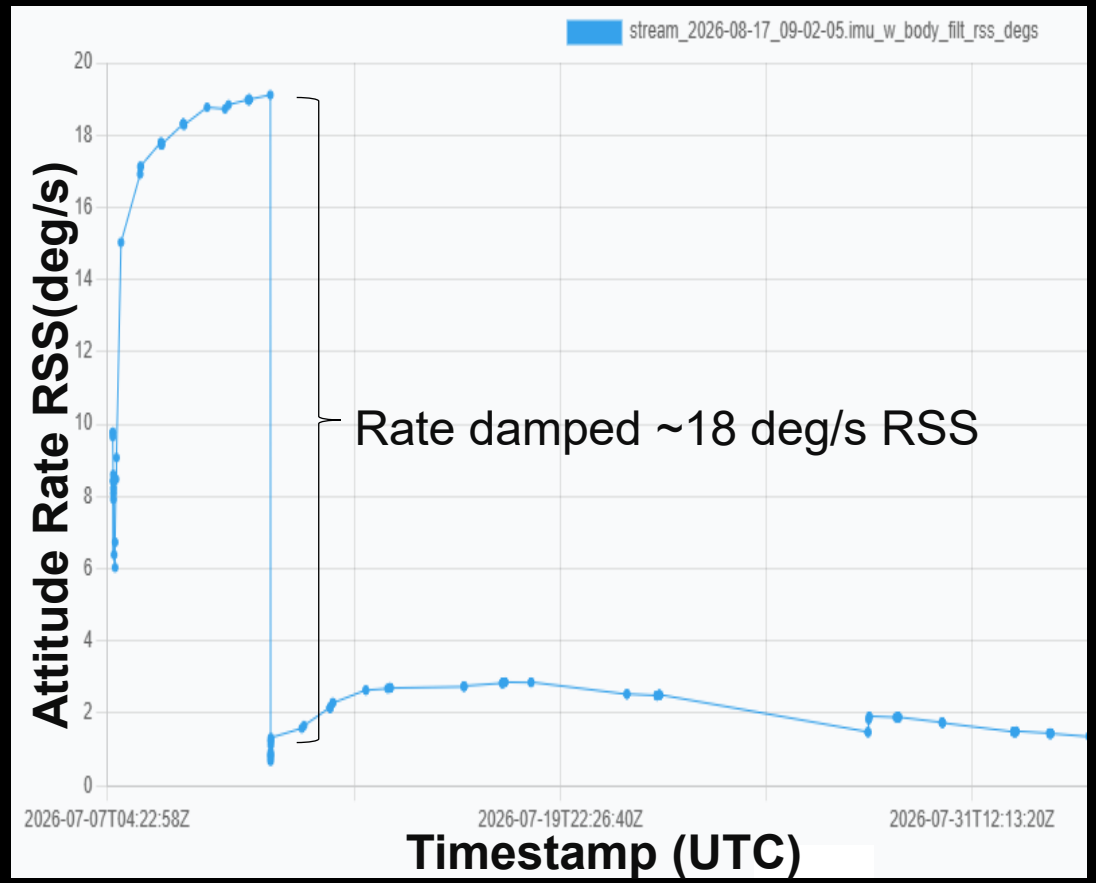
R5-S9: Results

Launched on Transporter 17

- Schedule: 4 months (design to delivery, approximate)
- Cost: $985k (includes launch, approximate)
- So far so good
  - Commissioned successfully
    - Prop system verified, damped attitude rate, payload SDA and radiation monitoring checkout complete (MDA in progress)
  - Completed 40 boot cycles over 41 days, downlinked ~99 KB so far

Next up

- Conduct payload pointing operations
- Attempt optical comm ground pass



Thank You! Questions?

3 spacecraft delivered and launched since the last Small Sat!

- Variety of missions/payloads/launches, so far so good...

We look forward to connecting with you

- Accepting payloads for 2027 launches
- Interested in sharing process and experience– please reach out!
- Interested in collaborating on efforts to reduce cost and schedule

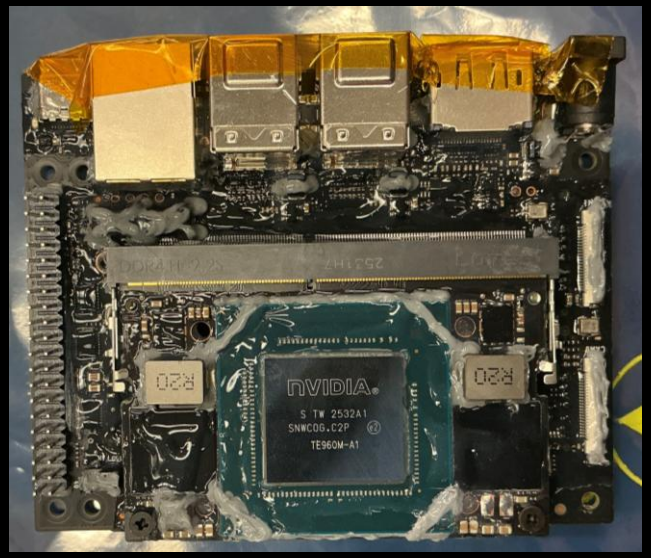
Contact R5 Project Manager Sam Pedrotty (samuel.m.pedrotty@nasa.gov)

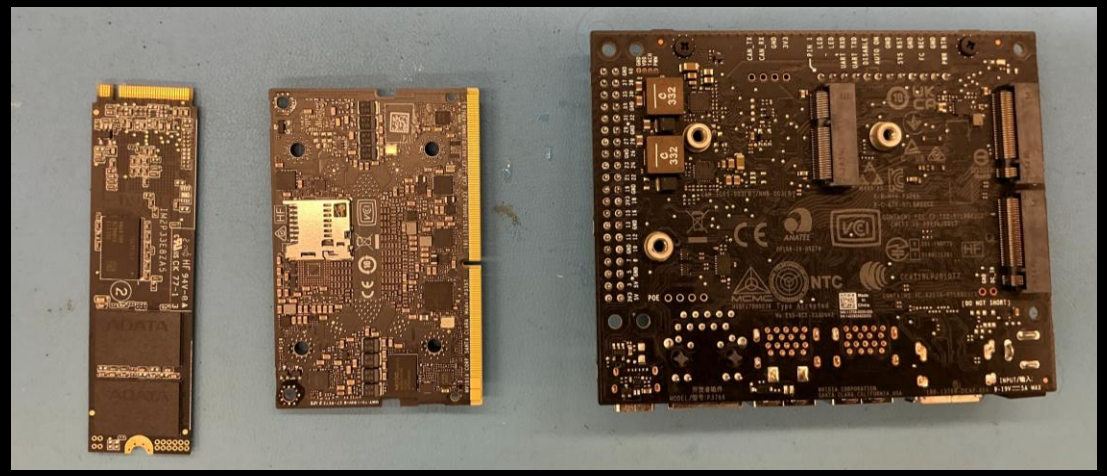
Special thanks to the R5 team and their families for their support, NASA RTMD, JSC/EA, Momentus, Sandia National Laboratories, The Aerospace Corporation, Solstar, SEOPS, SpaceX, Maverick, and the many others that made these missions successful.

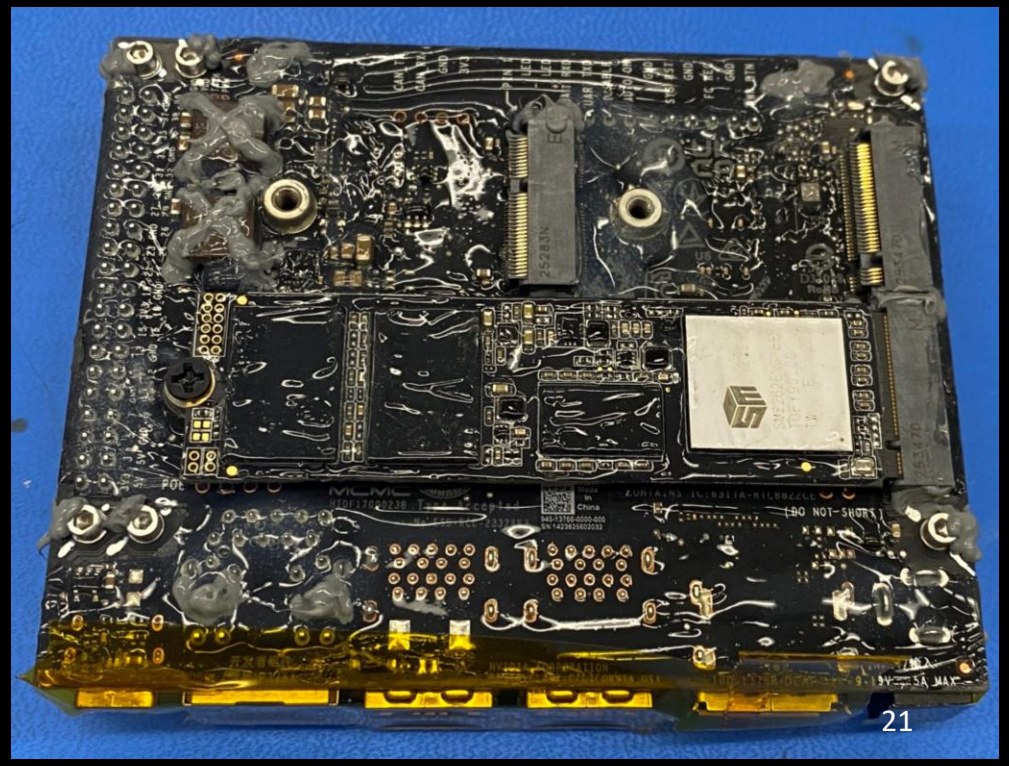
Backup

Jetson Preparation

1. Clean surface
2. Stake with DOWSIL 3145
3. Conformal coat w/ DOWSIL 3140
4. Apply thermal pads
5. Apply copper heat sink

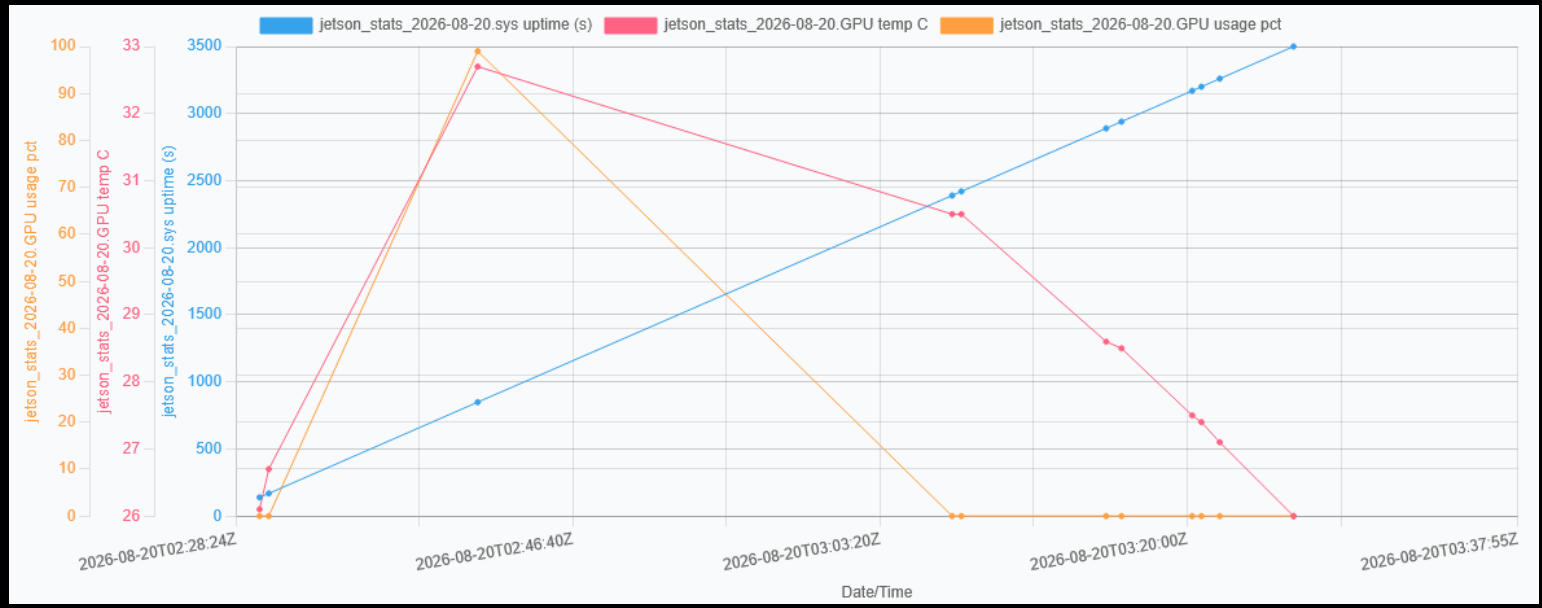


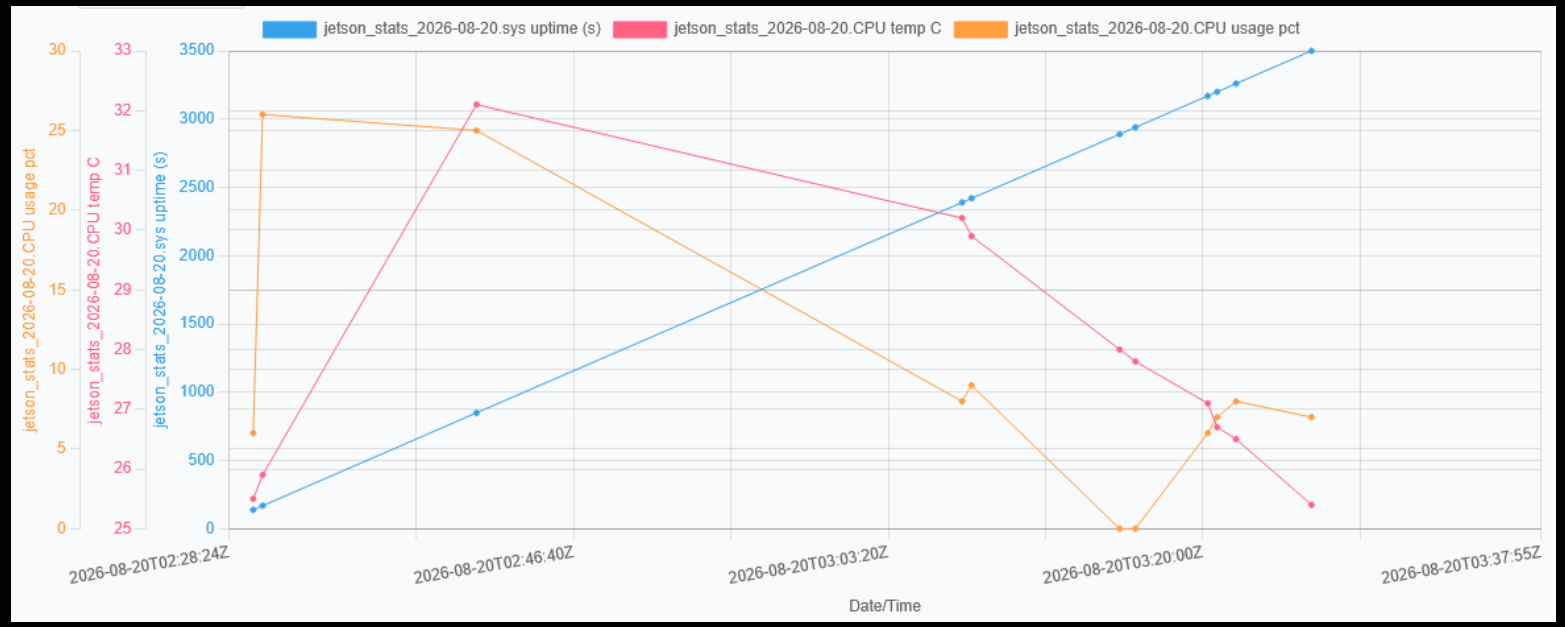




Jetson Data

Sample of data showing CPU usage, GPU usage, CPU temps, GPU temps, and Jetson uptime

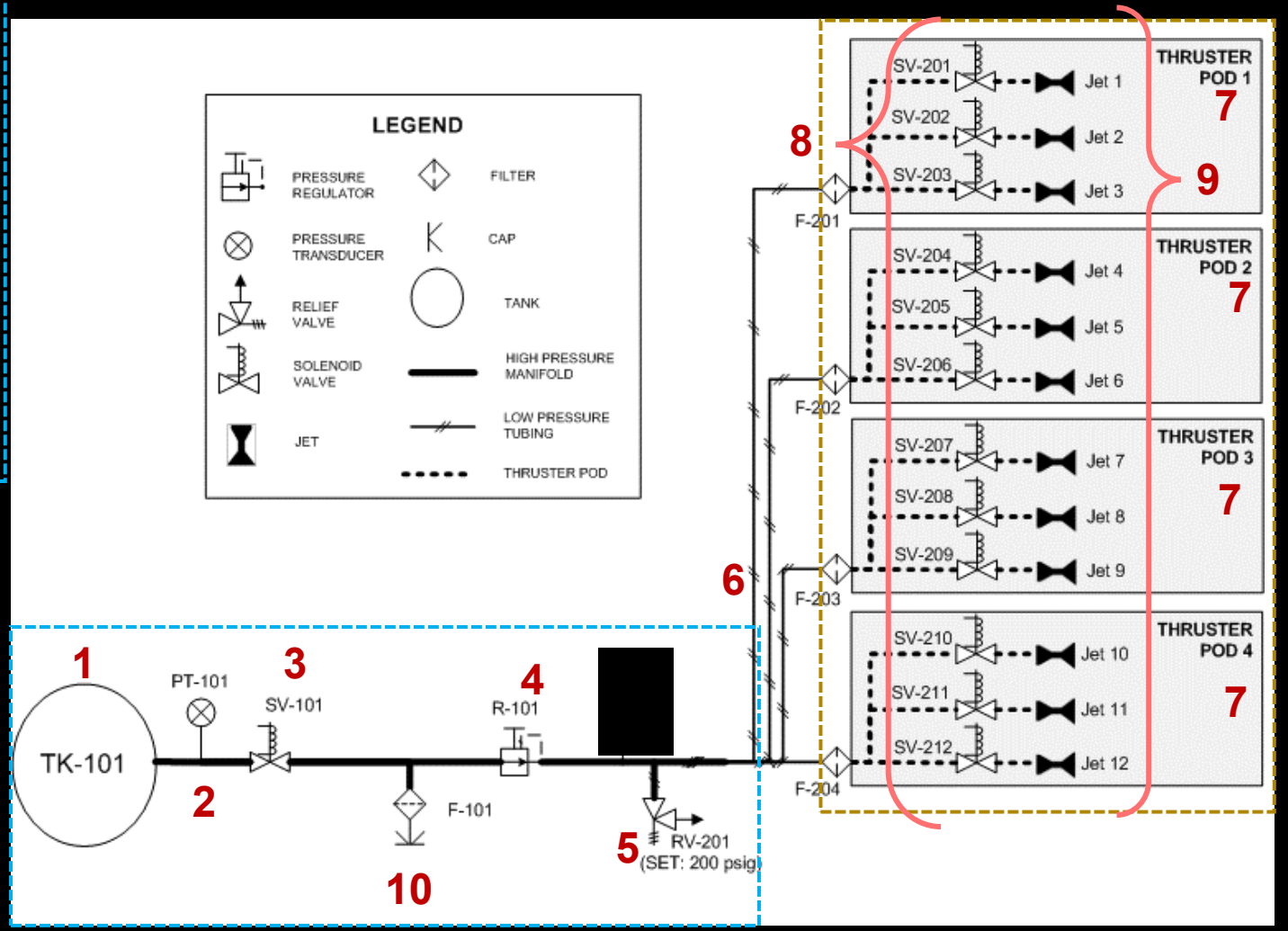




Prop System

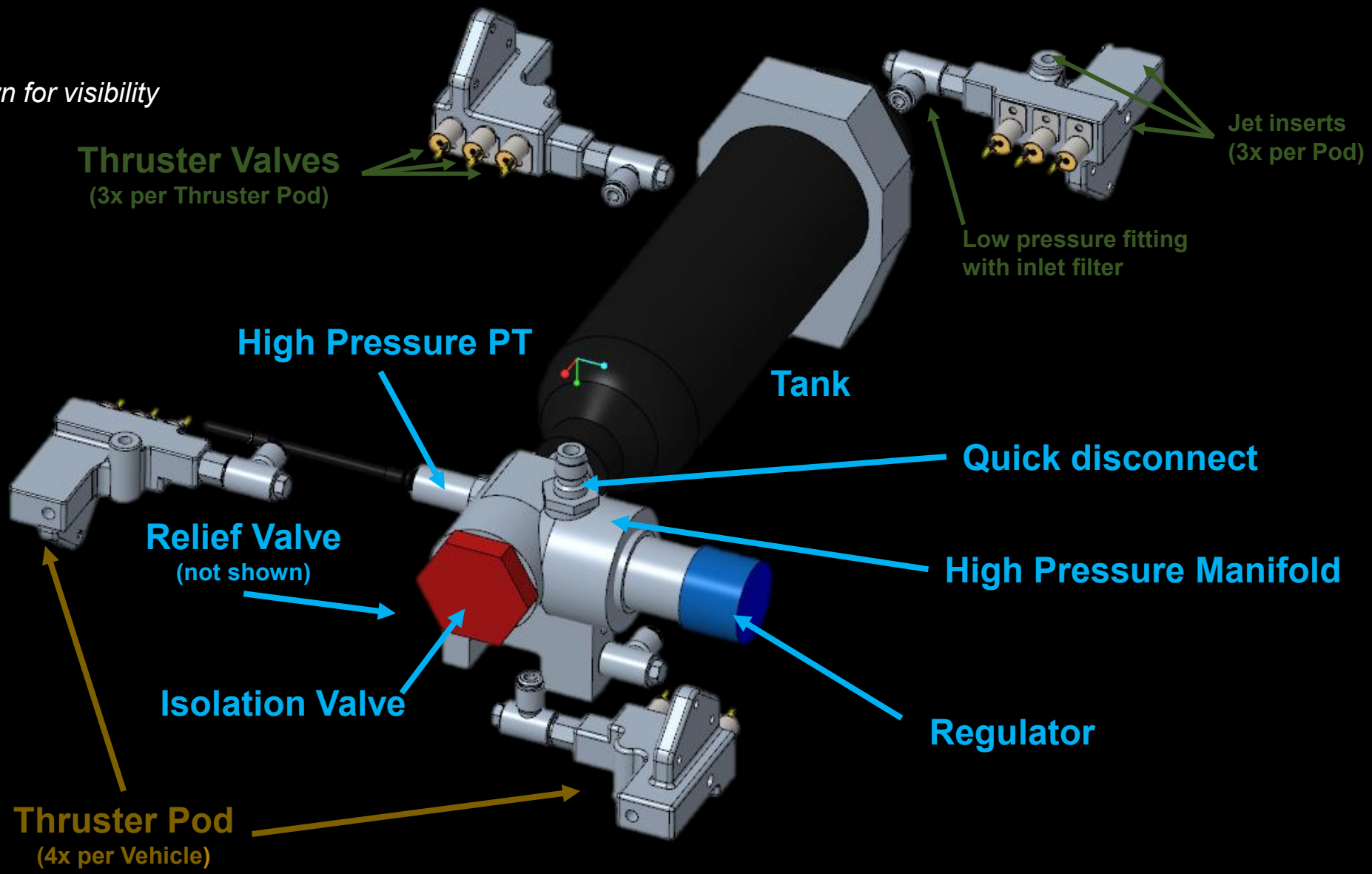
High-pressure Manifold

1. 13 cubic inch paintball tank (TK)
2. High Pressure transducer (PT)
3. Isolation valve (IV)
4. Regulator (R) reduces jet pressure to 60 psig
5. Relief valve (RV) protects against overpressure at 200 psig
6. Low pressure tubing to 4 thruster pods
7. Thruster pods (TP), 3 valves each
8. Thruster valves (TV), 12 total
9. Jet inserts (Jet), 12 total create C-D nozzle
10. Quick disconnect (QD) to refill tank



Prop System

NOTE: Tubing not shown for visibility



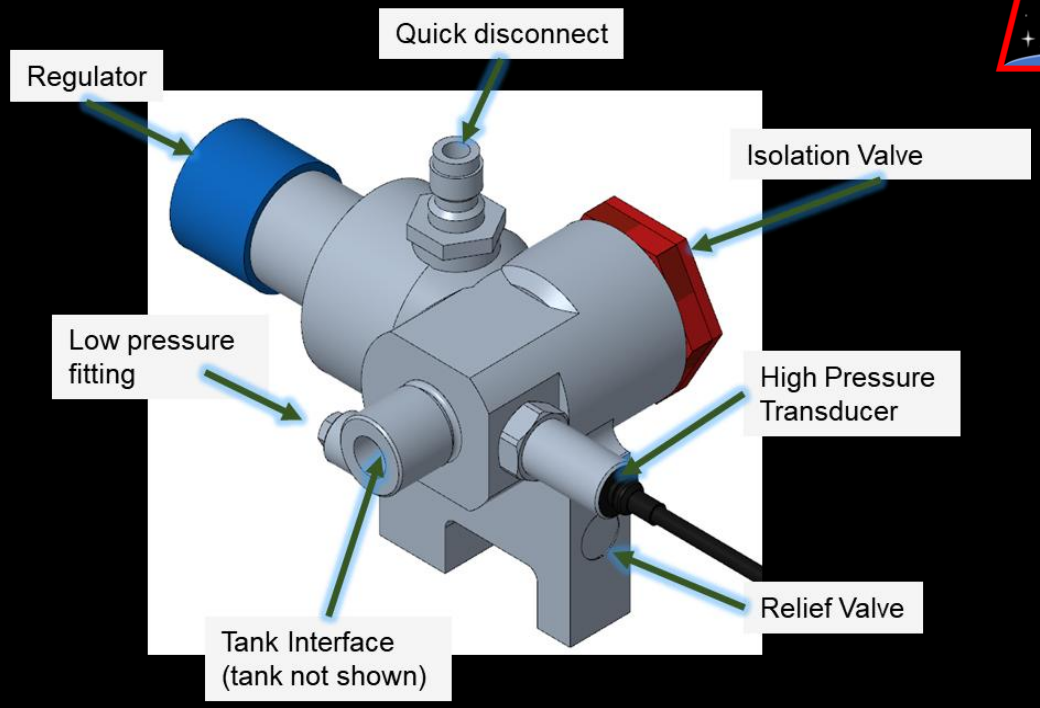
Prop System

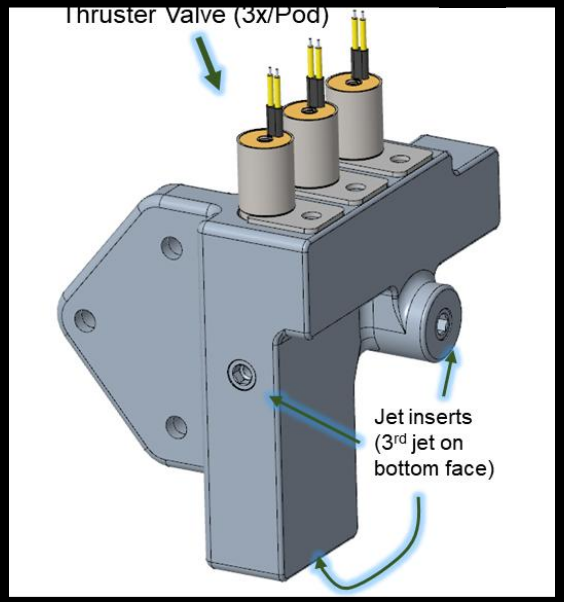
High Pressure

- **Tank** (not shown): aluminum DOT/S-081 compliant
- **High Pressure Manifold**: In-house design, traditionally-machined
- **Isolation Valve**: Lee Co SDPX series Solenoid
- **Regulator**: Paraplate 9014-4010, single stage, adjustable
- **High Pressure Transducer**: Measurements Specialty 0-5V output
- **Relief Valve**: Lee Co PRRA, 200 psig setpoint
- **Quick Disconnect**: Ninja o-ring fill valve for filling tank

Low Pressure

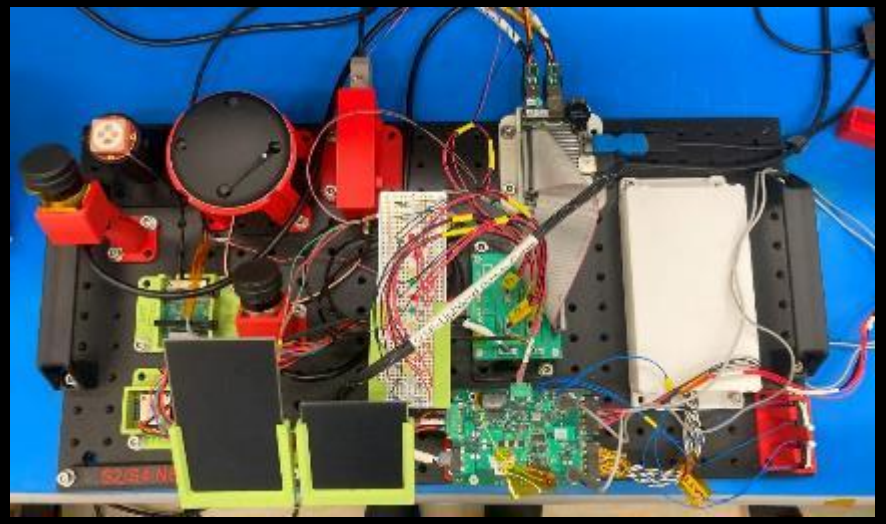
- **Thruster Valve**: Parker C07 cartridge-style solenoid
- **Jet Insert**: Set screw with C-D nozzle laser-drilled through
- **Thruster Pod**: In-house design, AM printed by Protolabs
- **Lines/fittings**: Beswick miniature 10-32 fittings and flexible tubing





Process Highlights

- **Reevaluate true payload requirements**
- **Optimize for recovery from failure rather than prevention of all failures**
  - Hardware-rich environment
  - Fully embrace C*OTS* wherever possible
  - Design for human error and handling
  - Optimize for ease of assembly and **disassembly**
- **Utilize failure tolerance to reduce process friction and expand test capability**
  - Lower barriers to hardware
  - Enable early integrated flight-like testing
  - Use *relevant data* to best identify where to use project resources
- **“Slow is smooth, smooth is fast”**
- **Architect project to enable iterative design**





R5 Reviews

- **MCR**
  - Describe need, concept, and how concept provides need
  - Describe rationale supporting design and expected performance
    - Can be heritage or basic analysis
  - Describe execution plan
  - Highlight risk
  - Customer reviews all information and accepts plan
- **FRR**
  - Describe final system design
  - Review artifacts showing system functions and is ready for flight
  - Customer reviews all information and verifies system is ready for flight
- **AAR**
  - Describe what was planned and what actually happened
  - Describe what was positive, what was challenging, and what needs to change for next time
  - Deliver lessons learned document to customer